INTERNATIONAL

RECOMMENDATION

OIML R 18

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Visual disappearing filament pyrometers

Pyromètres optiques à filament disparaissant

OIML R 18 Edition 1989 (E)

ORGANISATION INTERNATIONALE
DE MÉTROLOGIE LÉGALE

INTERNATIONAL ORGANIZATION
OF LEGAL METROLOGY

Foreword

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* *Note*: This publication is now under the responsibility of TC 11/SC 3 "*Radiation thermometers*".

VISUAL DISAPPEARING FILAMENT PYROMETERS

CHAPTER I

GENERAL

1 Scope

1.1. This Recommendation applies to visual pyrometers and micropyrometers[(*)] for measuring the radiance temperature of bodies in the visible and infrared parts of the spectrum, using the principle of the disappearing filament[(**)]. Temperatures in the infrared part of the spectrum are measured using pyrometers having an eyepiece incorporating an image converter.

1.2. The purpose of this Recommendation is te ensure the following.

1.2.1. All pyrometers with the same effective wavelength shall give the same indication (within the limits of permissible errors) when measuring the same temperature of the same body, whether or net it is a black body.

1.2.2. Pyrometers shall be calibrated and verified within the temperature range from 400°C to 6000°C, with the accuracy specified below.

1.3. The Recommendation prescribes for these instruments :

- the authorized units of measurement of temperature,
- the general technical characteristics,
- the principal parameters characterizing metrological qualities,
- the basic methods te be used te ensure uniformity of calibration and verification.

CHAPTER II

UNITS OF MEASUREMENT
TECHNICAL CHARACTERISTICS. METROLOGICAL CHARACTERISTICS

2 Units of measurement

2.1. Pyrometers shall be gauged according to the International (Practical) Temperature Scale[(***)].

The temperature shall be expressed :

- in degrees Celsius, °C
- or in kelvins, K

and designated t or T, respectively.

(*) Hereinafter called “pyrometers” except where a distinction needs te be made.

(**) The Recommendation also applies to visual grey wedge pyrometers if the physical conditions are appropriate.

(***) At the time of printing of this Recommendation the applicable scale is IPTS 68 which is expected to be superseded by ITS 90.

2.2. Pyrometers without direct temperature indication are admissible if the relationship between the value of the pyrometer lamp current and the temperature is known.

3 Technical characteristics

3.1. Pyrometers shall incorporate :

– all necessary optical components : objective, eyepiece…,

– a pyrometer lamp with power pack and devices to adjust and measure the current passing through the lamp. It is not necessary that the power pack and the adjusting and measuring devices form integral parts of the pyrometer,

– an absorption device designed to attenuate the apparent radiance of the targeted bodies whose temperatures exceed 1 400 °C or 1225 °C (see also point 4.3),

– either a red filter for pyrometers operating in the visible spectrum, or an infrared image converter with filter for pyrometers operating in the infrared part of the spectrum, or both.

3.1.1. The effective wavelength of pyrometers incorporating a red filter shall be (0.655 ± 0.01) µm.

3.1.2. In addition to the red filter it is permissible to use another selective filter whose effective wavelength is known.

3.1.3. The effective wavelength of pyrometers incorporating an infrared image converter shall be (1.00 ± 0.1) µm.

It is permissible to use such pyrometers with another value of the effective wavelength, provided that it is indicated.

3.1.4. Absorption devices used in pyrometers with an effective wavelength according to point 3.1.1 shall be such that the pyrometric attenuation value A(*) is constant within the limits of $\pm 1.5 \times 10^{-6} K^{-1}$.

3.1.5. Micropyrometers shall be capable of measuring the temperature of objects with dimensions(**) of the order of 100 µm and less.

(*) The pyrometric attenuation value, A, is defined as the solution of the following pair of simultaneous equations :

$$A = \frac{1}{T_0} - \frac{1}{T} \quad \text{and} \quad \int_0^\infty \lambda^{-5} e^{-\frac{C_2}{\lambda T}} \tau'\lambda \ \tau\lambda \ Y\lambda \ d\lambda = \int_0^\infty \lambda^{-5} \ e^{-\frac{C_2}{\lambda T_0}} \ \tau\lambda \ Y\lambda \ d\lambda$$

where :

T = the actual radiance temperature of a body
T_0 = the apparent radiance temperature of a body
τ_λ = the transmittance of the red filter
τ'_λ = the transmittance of the absorption device
Y_λ = spectral luminous efficiency
λ = the wavelength
C_2 = the second radiation constant.

(**) The “dimension of the object” is the minimum linear dimension characterizing the object, for example, the width of a tape, diameter of a circle, small axis of an ellipse, etc.

3.1.6. The filament of a pyrometer lamp shall be of such a form that the part of the filament to be used can be accurately defined : if the filament is rectilinear, the part of the filament to be used shall be clearly indicated.

3.2. The indicating device of a pyrometer may have one, two or more scales.

3.2.1. The scales shall be marked with the symbol for the unit used (°C or K), and a statement of the measuring range of the instrument for the scale in question.

3.2.2. A single instrument shall not have some scales graduated in degrees Celsius and others in kelvins.

3.2.3. The indicating device may have a true temperature scale for a given material. This scale shall be differentiated from the radiance temperature scales by the shape of the figures or the colour of the scale marks and figures.

4 Metrological characteristics

4.1. Pyrometers are divided into two accuracy classes : ordinary accuracy and high accuracy.

4.2. The metrological qualities of pyrometers are characterized by :

– bias error (*)

– repeatability error (**).

4.3. The bias and repeatability errors of pyrometers in service, under rated operating conditions, shall not exceed the maximum permissible values in the Table below.

Accuracy class	**Measuring range (1) (°C)**	**Maximum permissible bias error**	**Maximum permissible repeatability error**
		as % of the upper limit of the measuring range	
ordinary accuracy	400 – 800	± 1.5	1
	800 – 1400	± 1.5	1
	1400 – 2000	± 1.5	1
	2000 – 3200	± 2.5	2
	3200 – 6000	± 4.0	3
high accuracy	400 – 800	± 1.0	0.5
	800 – 1400	± 0.6	0.25
	1400 – 2000	± 0.6	0.25
	2000 – 3200	± 1.2	0.5
	3200 – 6000	± 2.0	1.0

(1) The limit of 1400 °C may be replaced by any value between 1225 °C and 1400 °C.

(*) The bias error is calculated as the difference between the mean of 5 measurements of the same radiance temperature and the conventional true value of this radiance temperature.

(**) The repeatability error is calculated as the difference between the maximum indication and minimum indication of the instrument in a series of 5 measurements of the same temperature of the same body.

Electrical measuring instruments shall be operated under their rated operating conditions.

Rated operating conditions are :

- ambient temperature : (20 ± 5) °C
- relative humidity : (65 ± 15) %
- absence of any external magnetic field apart from that of the earth.

The bias errors and repeatability errors for the Electrical measuring instruments are included in the above values, which are for the pyrometer as a whole.

4.4. The variation of the indications due to ambient temperature variations within operating temperature limits from 0 °C to + 40 °C shall not exceed half of the absolute value of permissible bias error for each variation of 10°C in air temperature.

4.5. When measuring the temperature of an object whose dimension is the minimum for a given micropyrometer the increase of error shall not exceed one half of its permissible bias errror.

4.6. Pyrometers with a lower limit of measurement in the visible spectrum of 700 °C (or 650 °C) are admissible, provided the bias error in the temperature range 700 °C to 800 °C (or 650°C to 800 °C) does not exceed 150 % (or 200 %) of that indicated for the range 800 °C to 1400 °C.

CHAPTER III

PYROMETER CALIBRATION

5 Method

5.1. Low-temperature scales "t_0" for pyrometers operating in the visible spectrum in the range 700 (650) °C to 2000 °C shall be calibrated by direct comparison with a standard instrument, either a standard thermometric lamp or a standard pyrometer in combination with a suitable source (thermometric lamp or black body).

The error of the standard instrument shall not exceed the maximum permissible value indicated in the Table below.

Measuring range (°C)	**Maximum permissible errors of the standard instrument (°C)**	
	for pyrometers of ordinary accuracy	**for pyrometers of high accuracy**
650 – 800	± 8.0	± 5.0
800 – 1400	± 4.0	± 2.5
1400 – 2000	± 6.0	± 4.0

5.2. High-temperature scales "t" for pyrometers operating in the visible spectrum, above 2000 °C shall be calibrated by :

- direct calibration of low temperature scales "t_0" as indicated above,
- using the pyrometric attenuation value A due to the absorption device,

– using the term Δt resulting from the divergence between the Wien and Planck equations at high temperatures, if appropriate,

and applying the formula :

$$\frac{1}{273 + t + \Delta t} = \frac{1}{273 + t_0} - A$$

which gives the value of the radiance temperature, t, represented by a certain scale mark on the high-temperature scale, as a function of the radiance temperature, t_0, indicated by the corresponding scale mark on the low-temperature scale.

5.2.1. The pyrometric attenuation value A is determined by measuring the apparent radiance temperature t_0 (*) of a standard for which the actual radiance temperature t is known and applying the formula :

$$A = \frac{1}{t_0 + 273} - \frac{1}{t + 273}$$

5.2.2. The values of Δt are given in the Table below ; they are the saure for all visual pyrometers with a red filter for which the effective wavelength has the value specified in point 3.1.1 of this Recommendation.

Temperature t (°C)	**Δt (°C)**	**Temperature t (°C)**	**Δt (°C)**
3200	0	4800	+ 15
3400	0	5000	+ 20
3600	+ 5	5200	+ 25
3800	+ 5	5400	+ 30
4000	+ 5	5600	+ 35
4200	+ 5	5800	+ 45
4400	+ 10	6000	+ 55
4600	+ 10		

5.3. The scales of pyrometers operating in the infrared part of the spectrum, over the range 400 °C to 800 °C, shall be calibrated by comparison with a suitable source, i.e. a black body or a standard thermometric lamp having a corrective filter (**).

In doing so, a standard thermometric lamp with a corrective filter shall be calibrated at the effective wavelength specified in point 3.1.3.

5.3.1. The error.in the temperature realised by the black body or the standard thermometric lamp with corrective filter shall not exceed one-third of the maximum permissible bias error for the pyrometer, in the given measuring range.

(*) The apparent radiance temperature t_0 of a body, at actual radiance temperature t, is the temperature at which the body when observed through a pyrometer wnthout interposition of an absorption device, has a radiance equal to the radiance which it shows when, at temperature t, it is observed through the saine pyrometer with interposition of the absorption device.

(**) The corrective filter ensures the equality of radiance temperature and colour temperature of the source.

5.3.2. The corrective filter may, for example, have a transmittance (with a standard deviation of 2 %) corresponding to the values indicated below :

λ µm	0.8	0.85	0.9	0.95	1.0	1.05	1.1	1.15	1.2	1.25	1.3
τ %	13	15	19	23	27	32	37	42	47	53	60

5.4. The calibration shall also include a check on the stability with time of the pyrometer lamps, to ascertain that the maximum permissible errors are not exceeded during the period of use of the pyrometer between two successive verifications.

CHAPTER IV

METROLOGICAL SUPERVISION

6 Metrological controls

When, in any country, visual pyrometers are subject to state metrological controls, these controls shall include, according to the internal legislation of the country, all or some of the following operations.

6.1. Pattern approval

6.1.1. Every pattern of a pyrometer from every manufacturer shall be subject to pattern approval.

6.1.2. No approved pattern may be modified without special authorization.

6.2. Initial verification

New, repaired or readjusted pyrometers shall be subject to initial verification.

6.3. Subsequent verifications

Subsequent verifications shall ascertain whether pyrometers in service have retained their statutory metrological qualities.

6.4. The procedures for and the period of validity of these controls are laid down by national regulations.

7 Calibration and verification

7.1. Visual pyrometers shall be calibrated and verified according to detailed specifications complying with this Recommendation.

7.2. All standard instruments (standard thermometric lamps or standard pyrometers) used for the calibration and verification of pyrometers, should be verified at least every two years.

7.3. To ensure the uniformity of high-temperature measurements, the various standard thermometric lamps and standard pyrometers shall be systematically compared.

8 Mark and certificate

Instruments which are successfully verified shall receive a verification mark or shall be accompanied by a certificate.

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